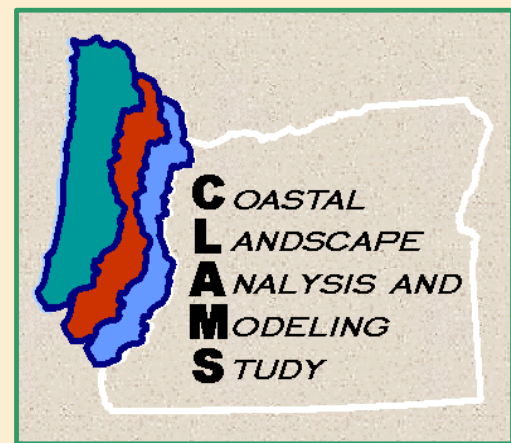


CLAMS Wildlife Habitat Capability Index Models

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Introduction

Forest management policies in the Pacific Northwest and the southeastern United States have previously been criticized for failing to maintain threatened species habitat or to provide habitat for early successional species. Thus, long-term forest policy planning requires the management of biodiversity on the landscape scale with coarse filters and fine filters. Coarse filters involve monitoring a variety of species through use of broad habitat requirements and assume that specific habitat requirements will be provided. The fine filter approach is designed to “catch” rare and noteworthy species that might otherwise slip through the coarse filter. CLAMS fine filter models do so by estimating habitat capability for 17 species through the use of multi-scale habitat relationship information from data sets, published research, and expert opinion.

Objectives

We developed a habitat modeling approach to evaluate forest management policies. Our approach has the following characteristics:

1. Quantify the current capability of sites across the Oregon Coast Range to provide habitat for focal species.
2. Provide spatially-explicit estimates of habitat capability for focal species for possible future landscapes.
3. Estimate the effects of alternative forest management actions, including silvicultural treatments, on habitat at stand and landscape scales.

Methods

The key to selecting species for the fine filter is to select focal species whose status and time trend provide insights into the integrity of the larger ecological system. This is accomplished by selecting species in categories that reflect ecological integrity and also societal concerns. This focal species approach differs from the more widely known indicator species concept because it examines species based on properties that are likely to be overlooked by the coarse filter (e.g., narrow endemism, ecological engineer, large home range, etc.), rather than species that might represent habitat needs of several species.

We developed a set of criteria and focal species that reflect characteristics of ecological integrity as well as societal concerns (e.g., listed and game species; Table 1). For each focal species we developed habitat-relationship models to characterize species occurrences and potential quality of habitat. Because habitat is species-specific, we assumed that no pre-defined vegetation classes could describe habitat suitability for all species. Thus, we developed a habitat suitability modeling approach based on the specific habitat elements as determined from the state of knowledge of the biology of the species.

We took a spatially explicit approach to modeling habitat for each of the focal species. In general, species’ habitat requirements were modeled from single pixels up to areas representing their home range (Fig. 1—pixel and circles). For species that operate from a central place (e.g., nest or den site), each 25- x 25-m pixel is evaluated relative to its potential to provide a nest or den site during the breeding season, based on the estimates of fine-scale features within the focal pixel and conditions surrounding it (a 9-pixel window of 0.56 ha surrounding the focal pixel). In addition, landscape scales relative to the species’ home range and other biologically relevant scales surrounding the focal pixel are evaluated for their ability to provide other life history requirements (Fig. 1).

Table 1. Focal species selected for fine filter modeling and the criteria for which they were selected.

| SPECIES | Focal Species Criteria | | | | | | |
|-----------------------------|------------------------|-------------------------|---------------------|------------------|--------------|--------------|----------------------------|
| | Risk | Seral Stage Association | Ecological Function | Umbrella Species | Link Species | Game Species | Public/Regulatory Interest |
| Northern Spotted Owl | X | X | | X | | | X |
| Marbled Murrelet | X | X | | | | | X |
| Pileated Woodpecker | X | X | X | | | | |
| Downy Woodpecker | | | X | | | | |
| Olive-sided Flycatcher | | X | | | | | |
| Western Bluebird | X | X | | | | | |
| Black-throated Gray Warbler | | X | | | | | |
| Northern Goshawk | X | X | | X | | | X |
| Mountain Beaver | | X | X | | | | |
| Red-tree Vole | | X | | | X | | |
| Long-legged Bat | X | X | | | | | |
| Marten | X | X | | | | | |
| Fisher | X | X | | | | | |
| Elk | | | | X | | X | X |
| Beaver Dams | | X | X | | | | |
| Torrent Salamander | X | | | | | | |
| Tailed Frog | X | X | | | | | |

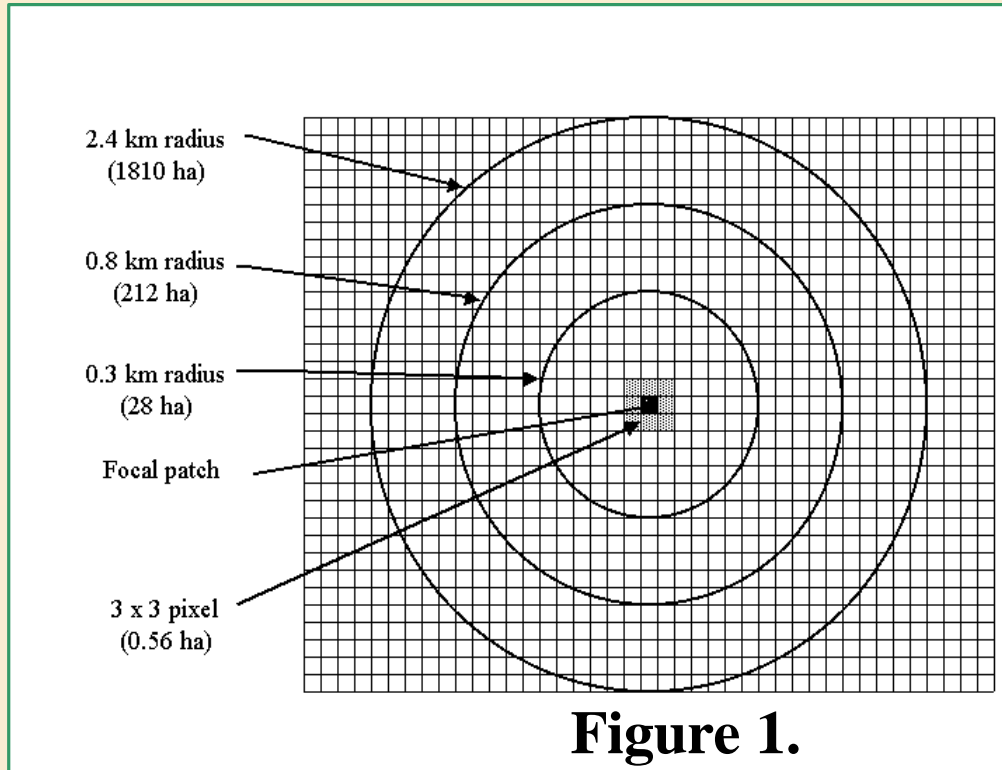


Figure 1.



Modeling Process

Determination of which variables to include in the model, their relationships, and the response of habitat capability to each variable begins with a literature review for the species (Fig. 2). Potential variables are evaluated based on four criteria:

1. There is an empirical relationship between reproduction or survival with the variable.
2. The variables can be estimated from existing GIS layers, including vegetation data.
3. The variable can be projected into the future using models of forest dynamics.
4. The variable has a noticeable influence on habitat capability for the species.

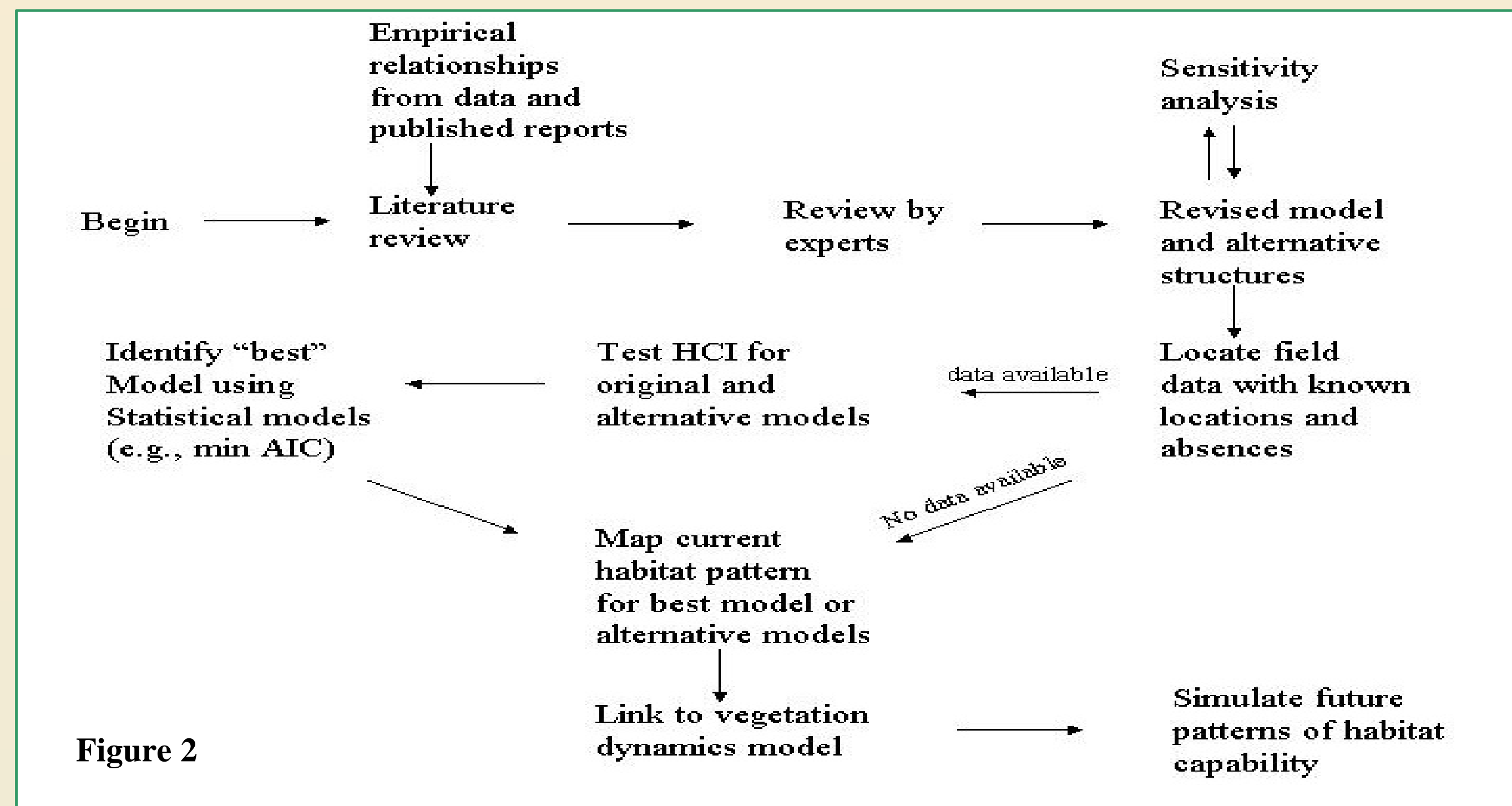
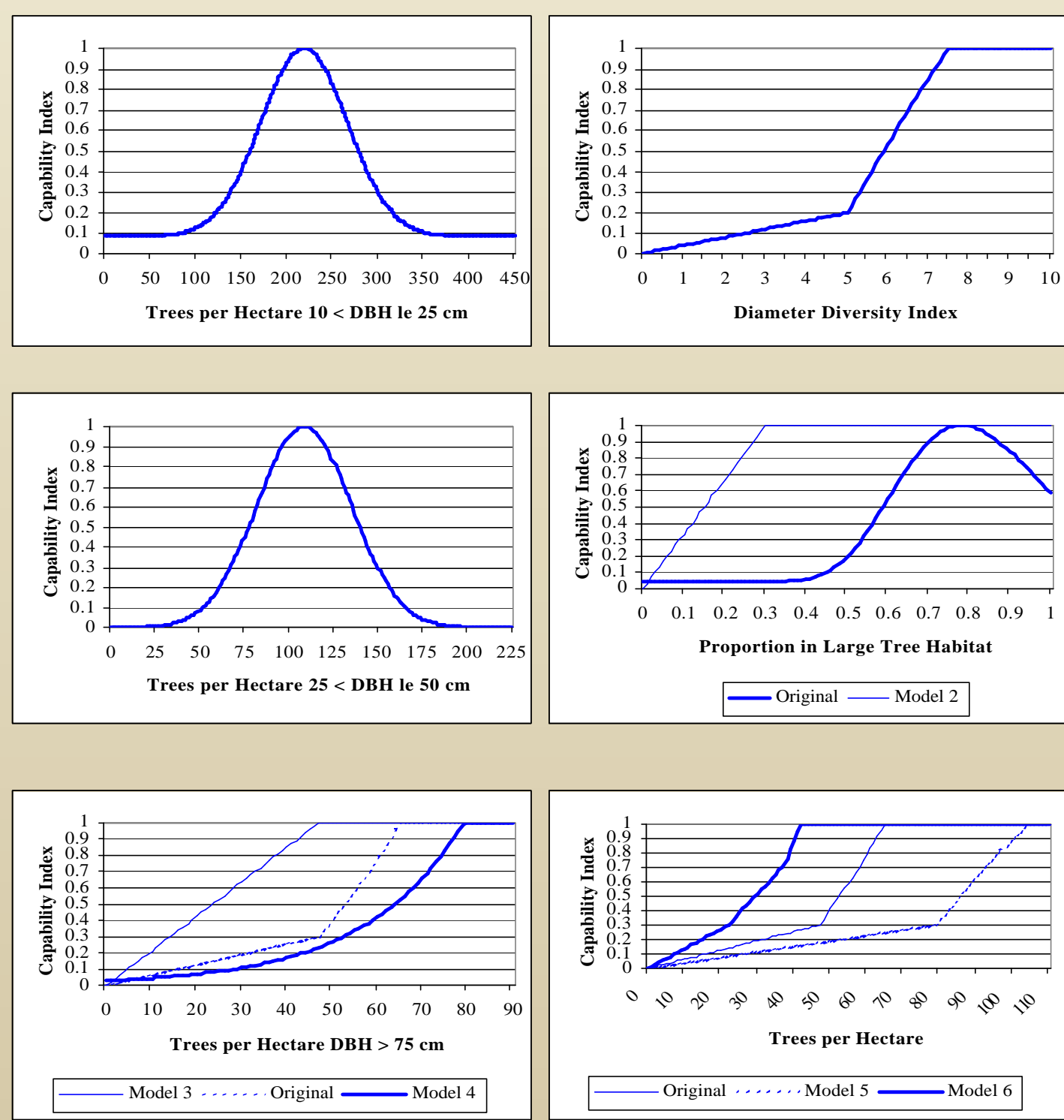


Figure 2

Examples of variables selected for the spotted owl HCI model, and their relationships, are outlined in Figure 3 (owl response function graphs and equations). The sensitivity analysis is conducted to ensure the range of variability for each variable is represented; this analysis is done for three watersheds in the Coast Range: Nehalem, Alsea, and Umpqua, to allow evaluation of northern, central, and southern watersheds, respectively (Fig. 4). This analysis is conducted with 1,000 Monte Carlo iterations using the Latin hypercube sampling method applied to the probability distribution of each variable. Correlation between HCI score and explanatory variable variation are then evaluated.



Equations for spotted owl model:

$$HSI_i = \sqrt[3]{NSI_i^2 * LSI_i}$$

where

HSI = habitat suitability index
 f = the focal pixel
NSI = nesting suitability index (Eq. 2)
LSI = landscape suitability index (Eq. 7)

$$NSI_i = \frac{\sum_{j=1}^n \frac{D1 + D2 + D3^2 + D4}{4}}{9}$$

where

NSI = Nesting Suitability Index
 f = focal pixel
 i = pixel
D1 = Index for the density of trees 10 < dbh # 25 cm
D2 = Index for the density of trees 25 < dbh # 50 cm
D3 = Index for the density of trees dbh > 75 cm
D4 = diameter diversity index

$$LSI_i = \sqrt[6]{S_1^3 * S_2^2 * S_3}$$

where

LSI = landscape suitability index for the focal pixel
 S_1 = habitat index for 0.3-km radius surrounding the focal pixel
 S_2 = habitat index for 0.8-km radius surrounding the focal pixel
 S_3 = home range index, representing a 2.4-km radius surrounding the focal pixel

Figure 3. Graphs and equations of spotted owl response functions.

Once the revised model and sensitivity analyses are completed, alternative models are developed, based on reviewer comments or competing hypotheses in the literature, to test individual variable response functions and the necessity of sub-indices (Table 2—list of owl hypotheses). This is accomplished through using field data with known locations and absences (Fig. 5—owl locations), and testing via an information-theoretic approach in logistic regression, with the HCI score as the explanatory variable. The hypothesis with the lowest AIC score is then identified as the “best” model hypothesis (Table 3—AIC results).

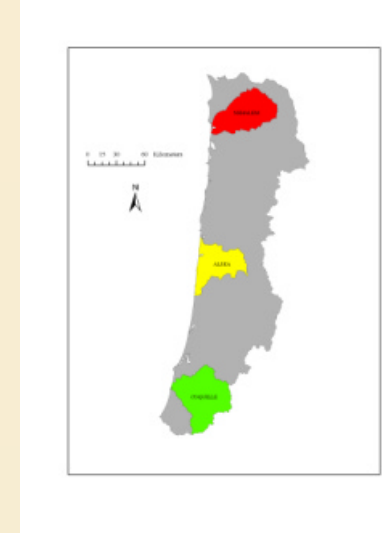


Figure 4. Watersheds from which sensitivity analysis data are derived.



Table 2. Alternative northern spotted owl model hypotheses.

| Model | Hypothesis |
|----------------|--|
| M ₀ | Original model hypothesis. |
| M ₁ | The surrounding landscape is not related to habitat capability for spotted owls (i.e., no landscape effect). |
| M ₂ | Habitat capability increases more rapidly with increasing area of large-tree stands within 0.3 km of spotted owl nests than in the original model. |
| M ₃ | Habitat capability increases more rapidly with more trees dbh > 75 cm. |
| M ₄ | Habitat capability increases more slowly with more trees dbh > 75 cm. |
| M ₅ | Potential nest trees are represented by the density of trees dbh > 50 cm. |
| M ₆ | Potential nest trees are represented by the density of trees dbh > 100 cm. |

Table 3. Validation regression and classification accuracy results for the original and six alternative northern spotted owl HCI models.

| Model | ▲AIC | HCI Breakpoint | Classification Accuracy (%) | Type II error (%) ¹ |
|----------------|-------|----------------|-----------------------------|--------------------------------|
| M ₂ | 0.0 | 0.37 | 75.5 | 10.0 |
| M ₅ | 4.75 | 0.28 | 75.5 | 11.6 |
| M ₆ | 8.12 | 0.29 | 75.8 | 12.3 |
| M ₄ | 8.26 | 0.28 | 75.8 | 11.9 |
| M ₀ | 8.56 | 0.29 | 75.5 | 12.4 |
| M ₃ | 10.27 | 0.24 | 76.1 | 8.4 |
| M ₁ | 11.56 | 0.33 | 72.6 | 13.6 |

¹The number of known spotted owl nests sites misclassified as unused sites, at the reported HCI breakpoint, divided by the total number of known spotted owl nest sites (n = 155) and multiplied by 100.

After the “best” model has been identified, it is then implemented to identify habitat capable for the species on a map of current vegetation (Fig. 6—owl hci map). This map is then linked with a vegetation dynamics model and we are able to evaluate future patterns of habitat capability. Where uncertainty exists in habitat-relationships, several different models can be estimated to show the range of uncertainty.

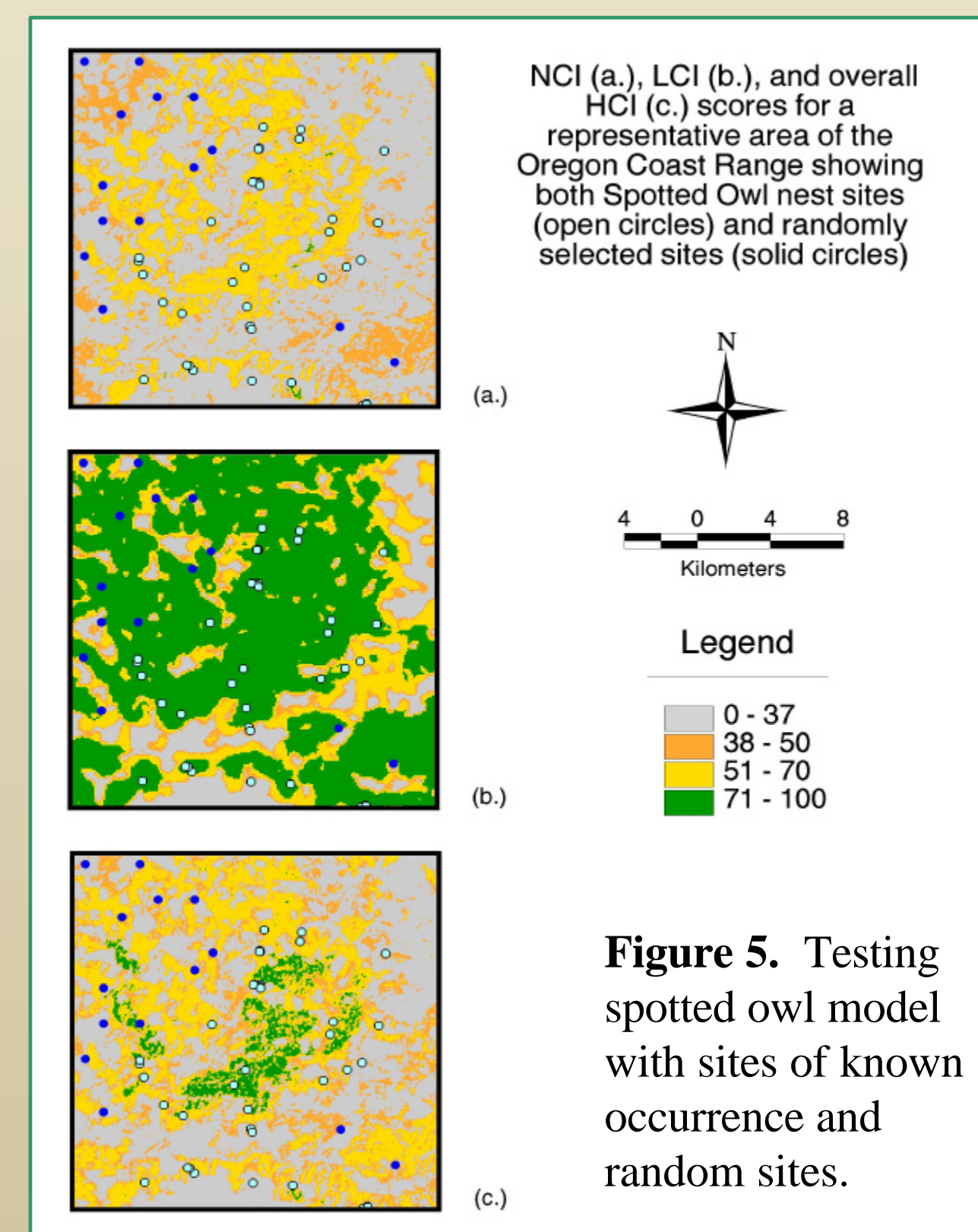


Figure 5. Testing spotted owl model with sites of known occurrence and random sites.

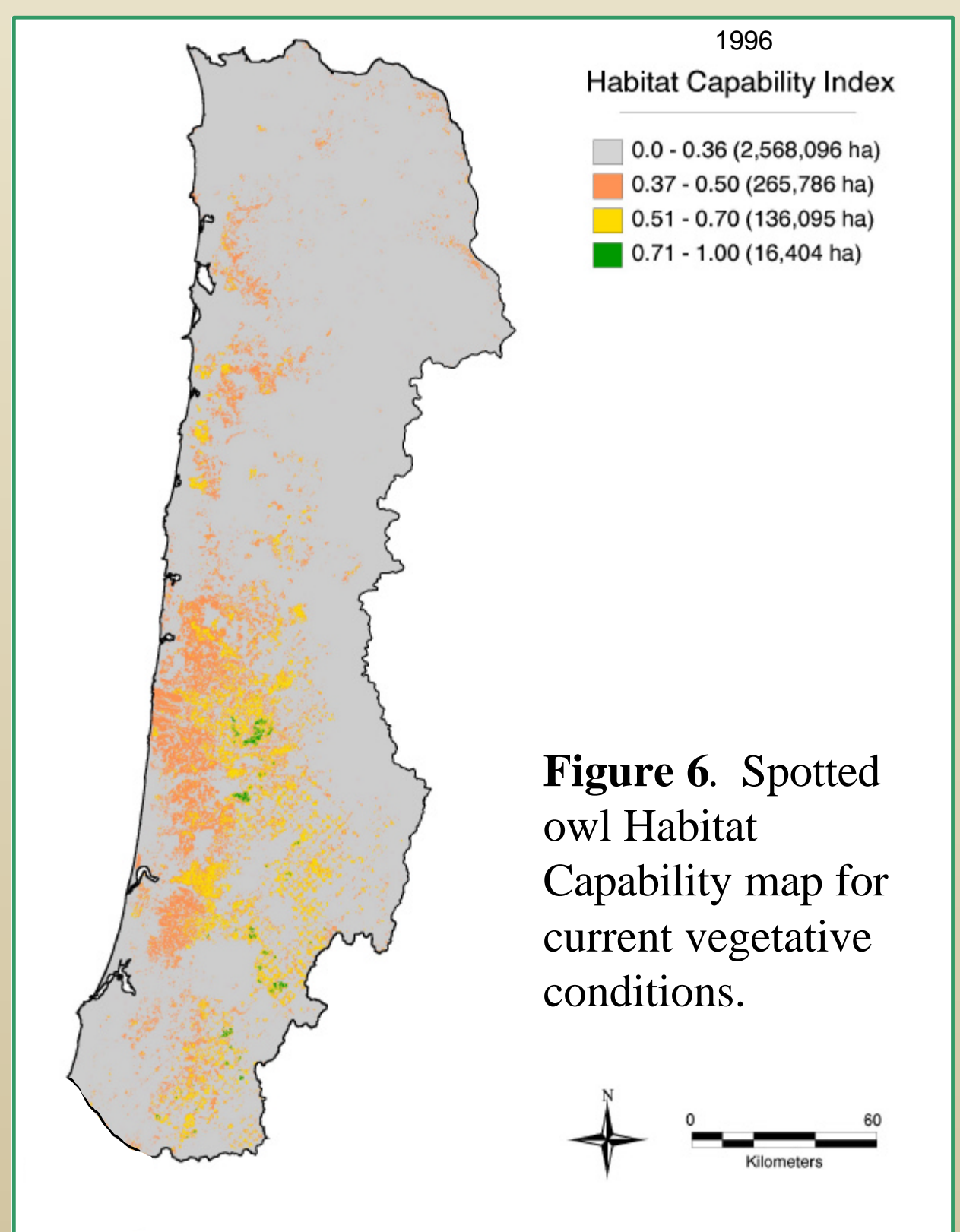


Figure 6. Spotted owl Habitat Capability map for current vegetative conditions.